REMARKS

Applicants acknowledge that Claims 19, 20, 22 and 23 have been withdrawn from consideration in this application, as being drawn to a non-elected species. Accordingly, the latter claims have been cancelled, without prejudice, however, to Applicants' right to resubmit them in the form of a divisional application, in their discretion. In addition, a new Claim 25 has been added. Accordingly, Claims 1-18, 21, 24 and 25 remain pending in this application.

Applicants acknowledge the Examiner's comments with regard to the citations contained in the specification. Accordingly, an Information Disclosure Statement has been submitted herewith. In this regard, Applicants note that German patent document DE 195 45 204 C1 is unavailable, and will be provided in a further Information Disclosure Statement once received. The relevance of the documents contained in the Information Disclosure Statement is discussed in the specification of the present application.

In response to the Examiner's comments with regard to the arrangement of the specification, appropriate headings have been inserted in the text, and additional revisions have been made to conform to customary U.S. practice.

Finally, in response to the rejection of Claims 1, 22 and 23, under 35 U.S.C. §112, second paragraph, Applicants have amended Claim 1 by changing the word "approximately" to "substantially". In this regard, Applicants refer to MPEP §2173.05(b)D, and respectfully submit that a person skilled in the art of thermomechanical steel processing would understand what is meant by the term "substantially straight". In this respect, Applicants note that the wording of Claim 1 is similar to that of *Andrew Corp. v. Gabriel Electronics*, 847 F.2d 819, 6 U.S.P.Q. 2nd (Fed. Cir. 1988), in which the Federal Circuit held that a person of ordinary skill in the art would know what was meant by "substantially equal". Accordingly, reconsideration and withdrawal of this ground of rejection are respectfully requested.

Claims 1, 3, 5-8, 10, 11, 15 and 17 have been rejected under 35 U.S.C. §103(a) as unpatentable over Kondo et al (U.S. Patent No. 5,873,960) while Claim 2 has been rejected as unpatentable over Kondo et al in view Bilgen et al (U.S. Patent No. 6,458,226); Claim 4 has been rejected over Kondo et al (cited previously) in view of Kondo et al '865 (U.S. Patent No. 5,938,865); Claims 9, 14 and 16 have been rejected as unpatentable over Kondo et al in view of Staat (U.S. Patent No. 4,798,071); Claim 12 has been rejected as unpatentable over Kondo et al in view of Poerink (U.S. Patent No. 3,988,915); Claim 13 has been rejected as unpatentable over Kondo et al in view of Poerink and further in view

of Seale et al (U.S. Patent No. 6,341,767); and Claims 18, 21 and 24 have been rejected as unpatentable over Kondo et al in view of Kuroda et al (U.S. Patent No. 6,372,056). However, for the reasons set forth hereinafter, Applicants respectfully submit that all claims which remain of record herein distinguish over the cited references, whether considered separately or in combination.

The present invention is directed to a method for thermomechanical treatment of steel rods. More particularly, the invention provides a method for the single-step skew rolling of steel rods in such a manner as to achieve a gradient in the degree of crystallization from the outside to the inside over the cross section of the rod, such that the treated rods have a strength profile on their cross section which reaches a maximum value in the marginal area (that is, the periphery) of the rod. To this end, the process according to the invention provides for heating the starting material, in the form of a solid steel rod, to a temperature that is above the crystallization temperature, so that it is austenitized. The steel rod is then held for temperature equalization, such that it assumes a substantially constant temperature along its entire length. While it is maintained at that temperature, the steel rod is then passed through a skew rolling stand in which it is skew rolled while it remains substantially straight, so that a predetermined twisting of the material in the marginal areas (that is, the periphery of the rod itself), and a desired transformation gradient are achieved

over the cross-section of the rod. After a critical degree of transformation is exceeded, dynamic recrystallization takes place and the rod is then reheated for final hardening and tempering.

According to a feature of the invention, which is recited in both independent Claims 1 and 25, as a result of the coordinated heat treatment and skew rolling of the solid steel rod, a desired transformation gradient and accordingly a recrystallization gradient, is achieved across the cross section of the rod. Thus, the degree of recrystallization varies from the center of the rod to the peripheral areas, where it is greatest.

Two objectives of the present invention are to intensify the refining of grain by recrystallization, and to improve the mechanical characteristics of the structure, particularly in the marginal zone (the peripheral area of the cross section of the rod), because it is here that the highest stress and the highest tensions occur in the case of a component which is stressed by torsion. As discussed in the specification of the present application, when transforming the solid material by skew rolling according to the steps of the invention, a gradient in the transformation degree is obtained, from the marginal zone to the center of the rod. That is, the structure of the marginal zone is transformed more than the center of the rod, so that the fineness of the recrystallized structure increases from the rod center to its marginal areas. As a result of the process specific

characteristics of skew rolling in conjunction with heat treatment, the desired structure changes are achieved.

The Kondo et al patent, on the other hand, is directed to a method of manufacturing seamless steel pipe. (See Column 1, lines 6-7; Column 3, lines 39-41 and 59-65.) For this purpose, as summarized at Column 3, line 45 through Column 4, line 4, Kondo et al provides a method in which a billet having a round cross section is first cooled, and then heated (step 3) to a temperature not higher than the A_{r1} transformation temperature to a temperature which allows piercing the billet. In step 4, the billet is then pierced "so as to obtain a hollow shell". Thereafter, in step 5, a steel pipe is produced by "elongating and finish rolling the hollow shell using a continuous elongating mill and a finish rolling mill which are directly connected with each other...." Thereafter, the pipe is heated for recrystallization, quenched and tempered.

As is apparent from the foregoing brief description, the Kondo et al reference differs substantially from the present invention, which (as noted above) is directed to a process for providing a steel rod having a degree of crystallization which varies according to a gradient, from its center to its periphery, so as to provide a desired mechanical strength profile. This feature of the invention is recited in both of independent Claims 1 and 25. Claim 21, for example, recites a step of "causing said rod to be transformed by skew rolling,...such that a

predetermined twisting on the material in a marginal area and a desired transformation gradient are achieved over a cross section of the rod." Similarly, Claim 25 recites a step of "causing formation of a desired gradient in the degree of recrystallization of steel of said rod over a cross section of said rod, with a marginal area having a fine-grained martensite structure, whereby said rod has a cross sectional strength profile that reaches a maximum value in said marginal area of said rod". Claim 25 further recites the steps by which such formation of a gradient is brought about.

The foregoing limitations of Claims 1 and 25 are not taught or suggested in Kondo et al. In particular, since Kondo et al is directed to the manufacturing of seamless steel pipe, it contains no feature which corresponds to the steps defined in Claims 1 and 25 whereby the cross sectional area has a crystallization structure which varies from its center to the marginal area. Indeed, an essential feature of the Kondo et al process resides in piercing the billet in such a manner as to produce a "hollow shell". (See Column 3, line 58.) Accordingly, there is no steel in the interior of the structure, and the concept of a gradient of the material over the cross section of a solid rod has no analog in Kondo et al. Not surprisingly, therefore, Kondo et al contains no teaching or disclosure which suggests the creation of such a gradient.

In this regard, Applicants note that the invention defined in the present application resides in the overall combination of steps, which are in fact applied specifically to a solid steel rod, and which achieve a specified structural transformation of the interior of the steel rod (that is, across its cross section). While Kondo et al provides steps of heating and forming, its sole purpose is to change the shape of the work piece, and not achieve a defined distribution of the structural state and of the structural characteristics over the cross section of the pipe, which is of course hollow. Thus, Kondo et al deforms the pipe in order to use the elongation/distortion of the structure which occurs as a result of the deformation. Kondo et al therefore requires a two-step deforming process, including both elongating and finish rolling. By contrast, the present invention provides a single step process for thermomechanical treatment of solid steel rods which has no analog in Kondo et al.

The remaining references referred to in the Office Action have been cited in respect of specific dependent claims, and the features recited therein. Applicants note in this regard that none of the references sets forth a process for thermomechanical treatment of steel rods which includes the features of Claims 1 and 25. Indeed none of these references deals with or addresses the problems solved by the present invention of how to provide a gradient in the crystalline structure of the steel in a steel rod, and accordingly, a gradient in the strength

profile, across the cross section of the rod. Moreover, none of the cited references teaches or suggests the particular combination of steps defined in Claims 1 and 25, the totality of which achieves such a result. Accordingly, these prior art documents do not suggest a modification of Kondo et al which would replicate the invention.

Another feature of the invention which is not taught or suggested by the cited references is recited in Claim 7, and in Claim 25. In particular, Claim 7 provides that the heating temperature of the rod is kept constant until its entry into the roll gap, so that it remains at the equalized temperature as it proceeds through the skew rolling process. Similarly, Claim 25 recites a step of skew rolling the straight rod with the rod "entering said skew rolling while it remains at said equalized temperature". This combination of maintaining the temperature of the rod constant until it enters the skew rolling process, together with the skew rolling itself, has the result of permitting the type of transformation of the surface area of the rod due to the inclination of the skew rollers, to a greater degree than at the interior of the rod, which is the process by which the desired gradient is achieved. This feature of the invention is also not taught or suggested in the cited references.

With regard to particular references, Applicants note the following:

The Bilgen et al patent discloses a process that is designed for cold-formed springs in that it tempers directly after the thermomechanical deformation, and winds the spring only later. The targeted shaping of the structure as a result of the deformation is not described.

Poerink, on the other hand, involves the winding of coil springs from cold wire, not hot, as in the present application. Moreover, Poerink involves "tension springs", which are draw springs and not coil compression springs. Thus, it provides "piano wire" as an example. In Poerink, before winding in the cold condition, the wire is provided with a "pre-stress" by twisting about the wire axis, without permanently deforming its structure in this direction. (That is, there is no plastic deformation.) Accordingly, the Poerink patent differs substantially from the present invention.

Neither Poerink nor Seale et al involves the alignment of the structure of the steel in the direction of a later stress. (Compare Claim 12.) While Poerink mentions the introduction of a pre-stress, as discussed above, Seale et al contains no discussion at all regarding the structure of the wire. In this regard, Applicants note that the Office Action refers to the relationship between the angle of twist (in the case of stress), the G-modulus, and the wire diameter in connection with Seale et al. The referenced discussion, however, pertains only to the issue of what angle a spring wire of a certain diameter twists when a certain

load acts upon the spring. This general spring theory, which is well known does not suggest, however, the alignment of the structure of the wire in a certain direction, as described, for example in Claim 13.

The Kuroda et al patent discloses a process which focuses on improvement of the capacity of the wire to be drawn. It is apparent to a person skilled in the art, that the Kuroda et al process is intended for cold winding, and not for hot winding of springs. According to Kuroda et al, the wire (having a certain composition and mechanical characteristics) is drawn and peeled and subsequently directly hardened in oil and tempered to the desired strength. Only thereafter will the spring be wound from the cold harden wire. If the wire produced according to Kuroda et al were subsequently heated in order to wind it hot, it would lose the structural characteristics obtained by the hardening and tempering. It would therefore have to be replaced, but then, after hot winding, would have to be tempered.

Accordingly, for the reasons set forth above, Applicants respectfully submit that all claims which remain of record in this application distinguish over the cited references, and are allowable.

In light of the foregoing remarks, this application should be in consideration for allowance, and early passage of this case to issue is respectfully

requested. If there are any questions regarding this amendment or the application in general, a telephone call to the undersigned would be appreciated since this should expedite the prosecution of the application for all concerned.

If necessary to effect a timely response, this paper should be considered as a petition for an Extension of Time sufficient to effect a timely response, and please charge any deficiency in fees or credit any overpayments to Deposit Account No. 05-1323 (Docket #103020.59950US).

Respectfully submitted,

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